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GB 2018393 A

(58) Field of search
UK CL (Edition J) **F2U**
INT CL[4] **F16D 3/00**

(54) **Constant velocity ratio universal joint of the tripod type**

(57) A constant velocity ratio universal joint of the tripod type, comprising an inner joint member (10) with three outwardly extending arms carrying rollers (21) engaging in guide grooves (20) in an outer joint member (11), the rollers being constrained to roll along the guide grooves without tilting therein and being able to rotate about, slide lengthwise of, and tilt relative to the arms of the inner joint member. Each arm (14) has a part-spherical surface on which is received an inner roller element (22) so as to be able to tilt on the arm, the inner roller element (22) having a cylindrical external surface (24) on which roller (21) is able to rotate and slide.

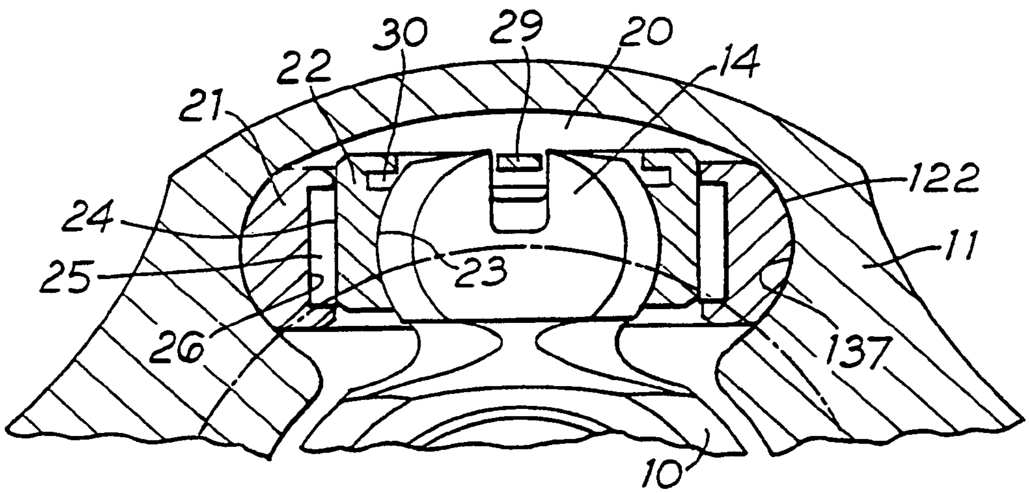
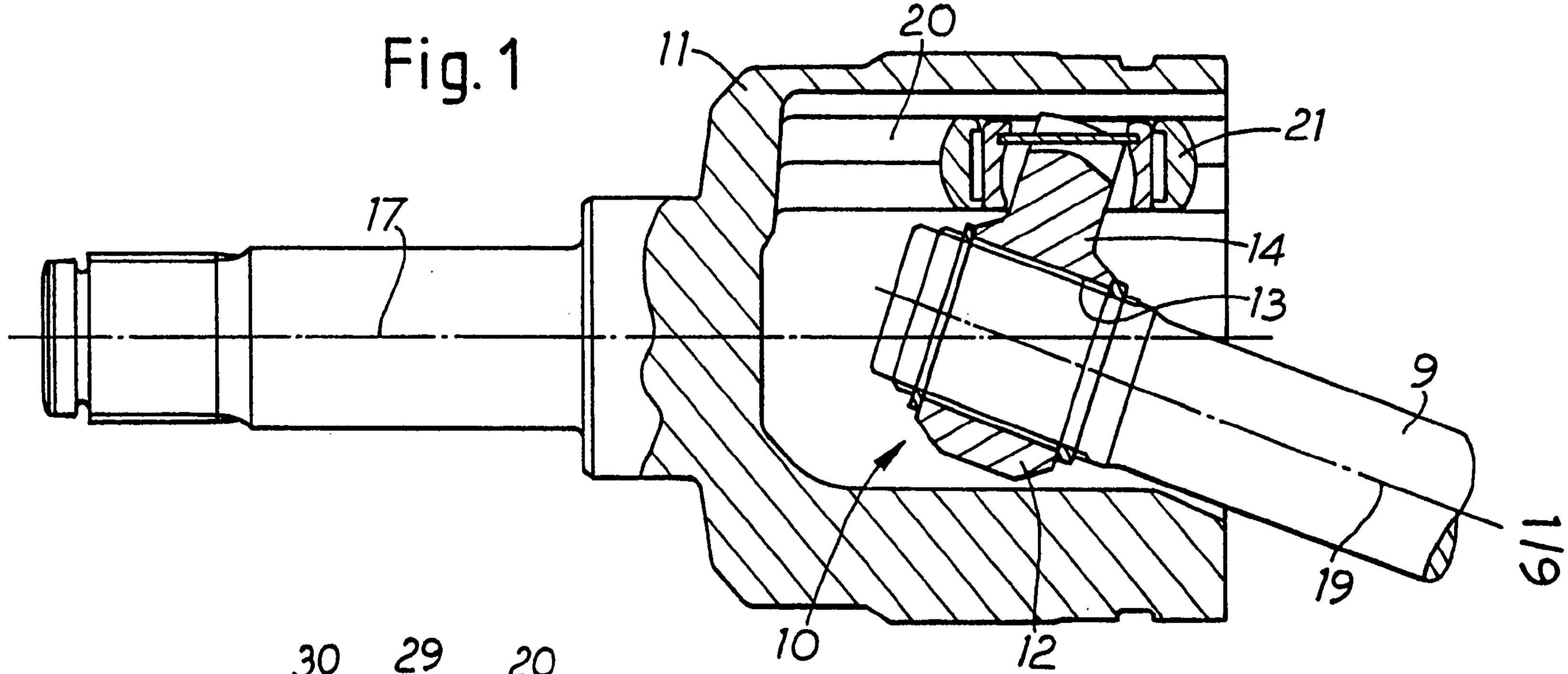


Fig. 2

GB 2 226 102 A

Same as WO/07067

Fig. 1



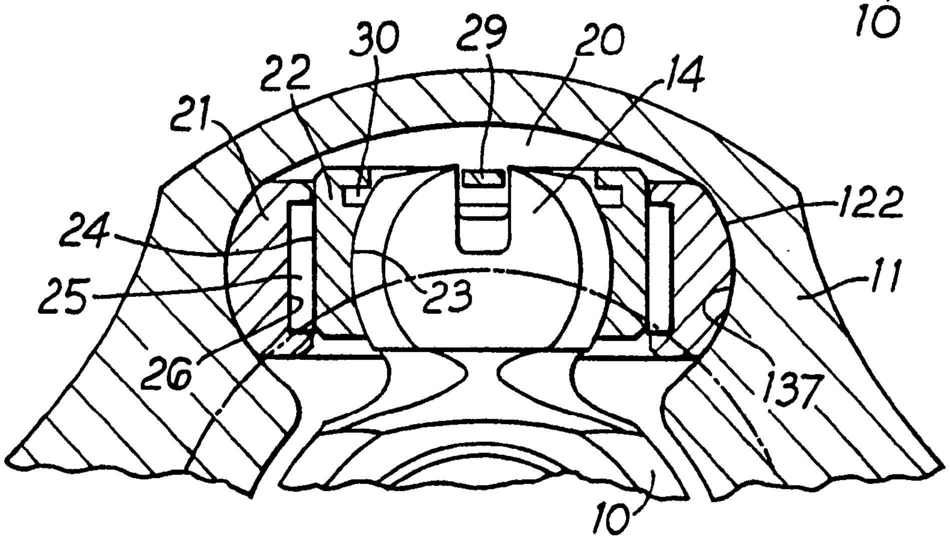


Fig. 2

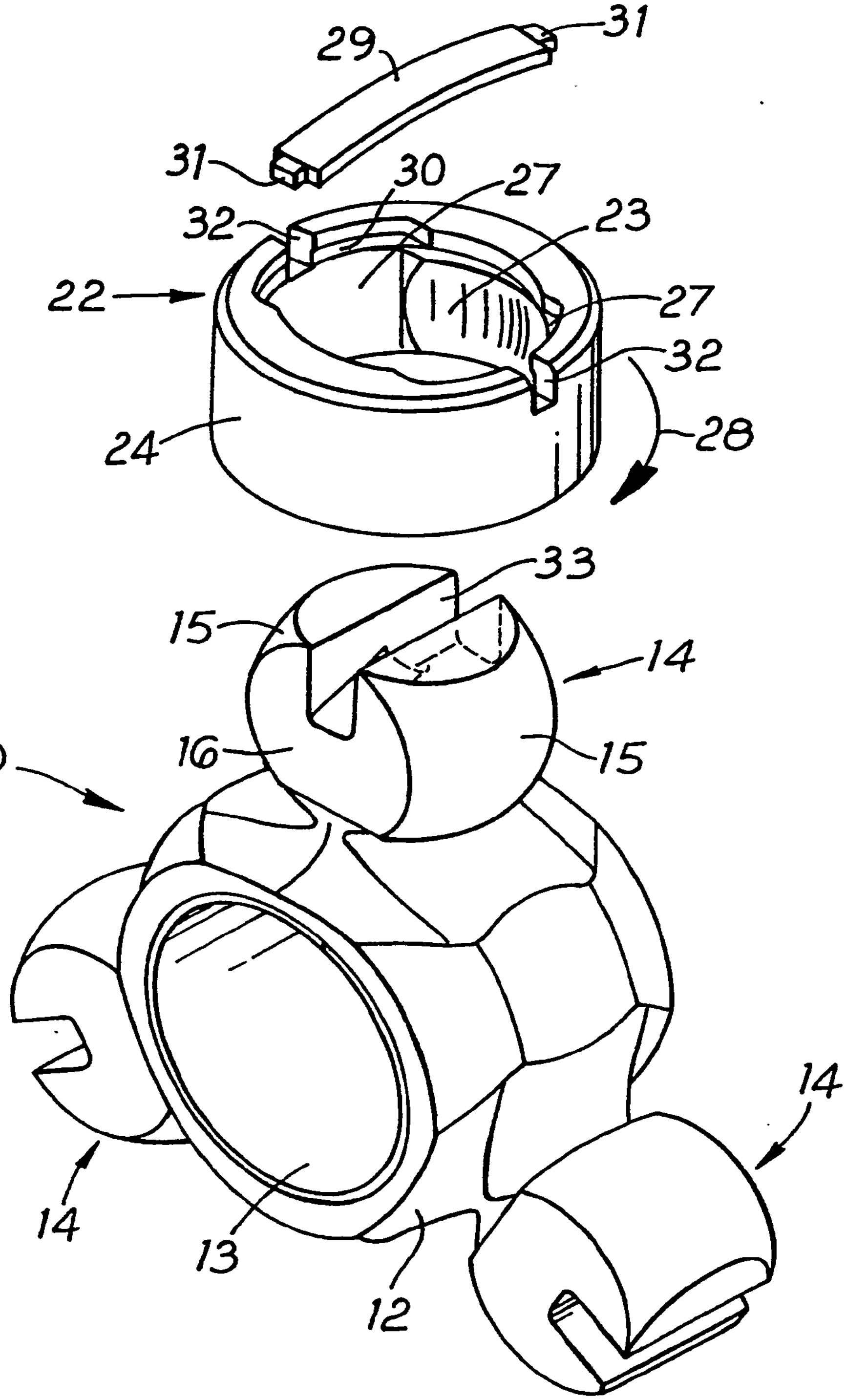


Fig. 3

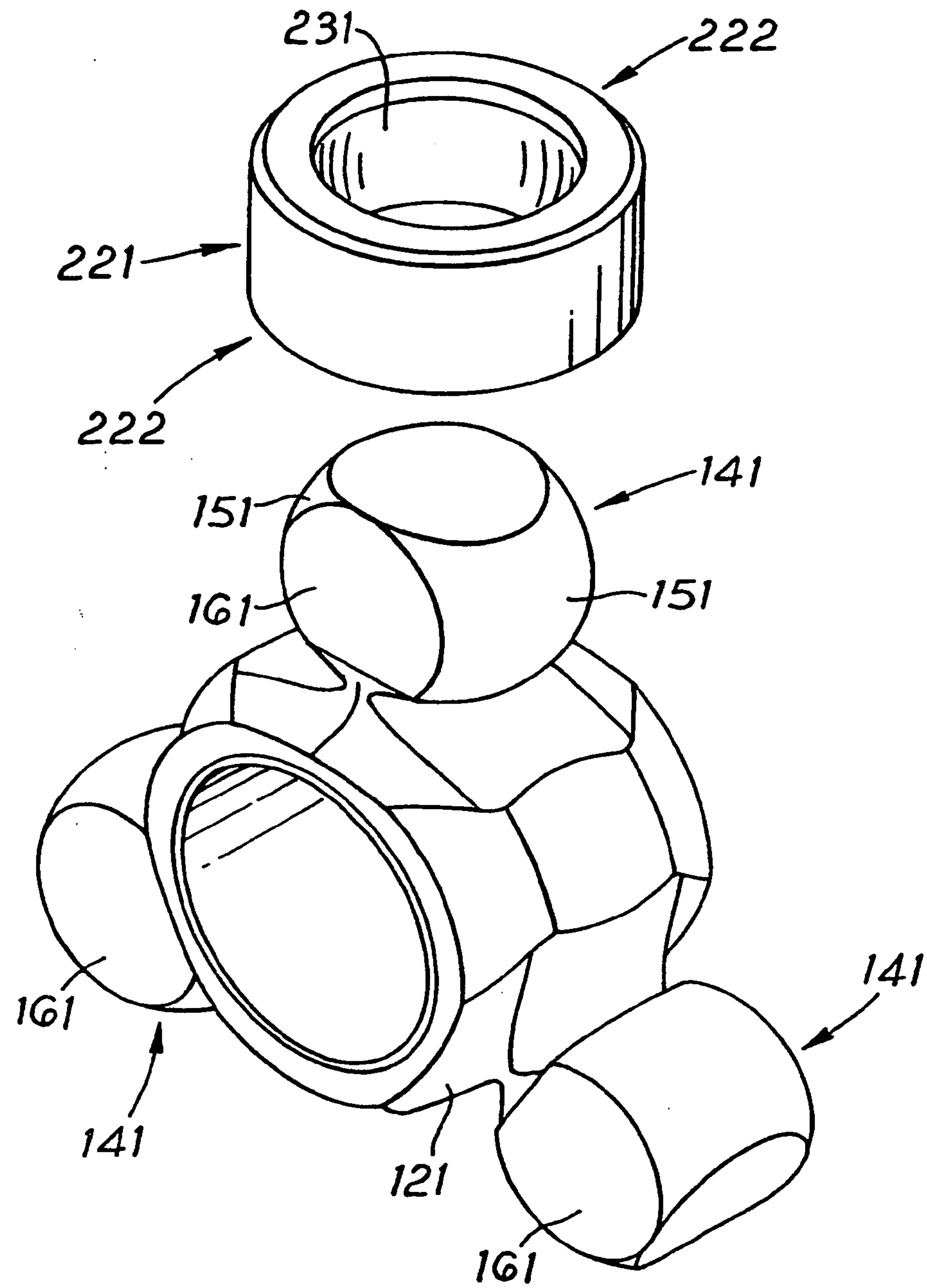


Fig. 4

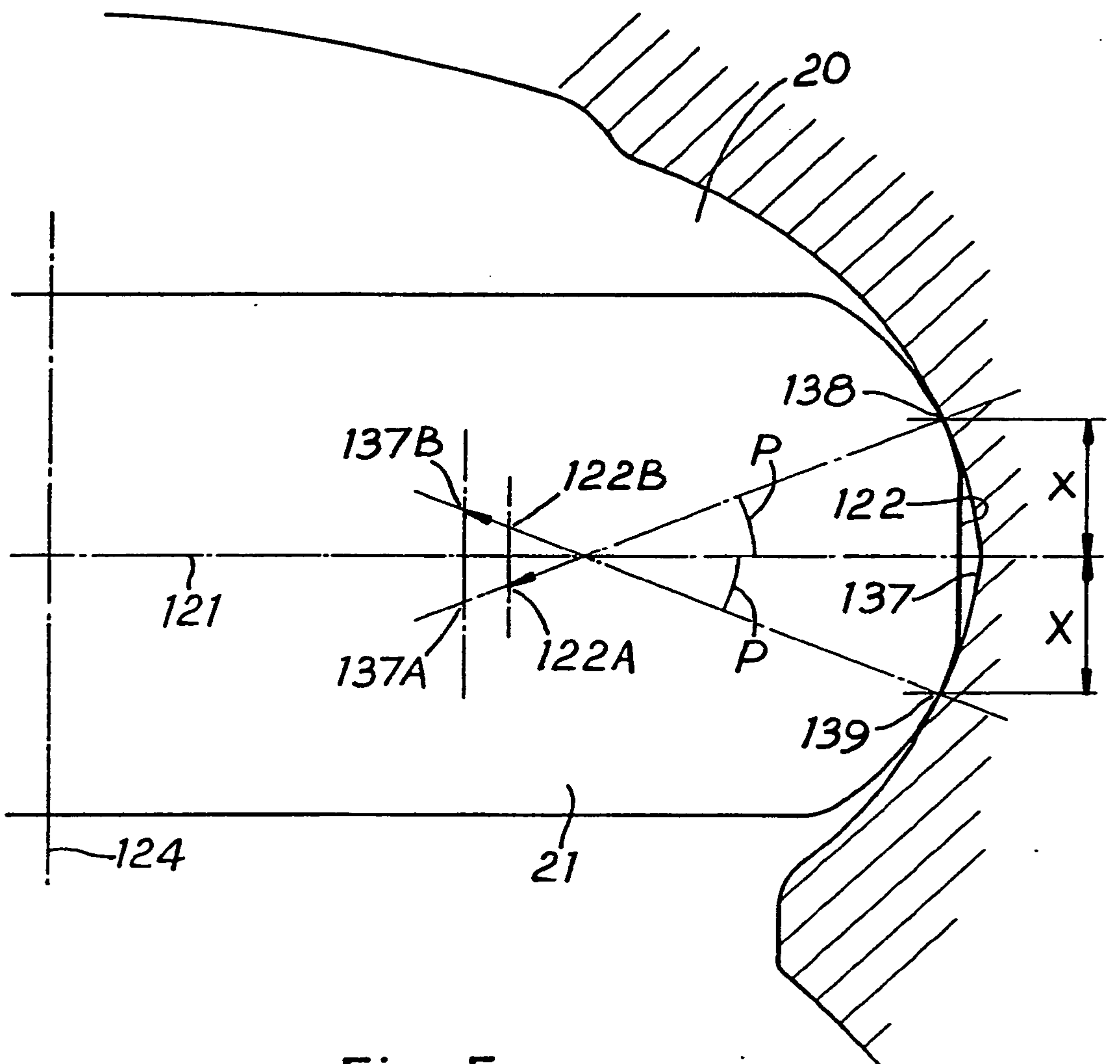


Fig. 5

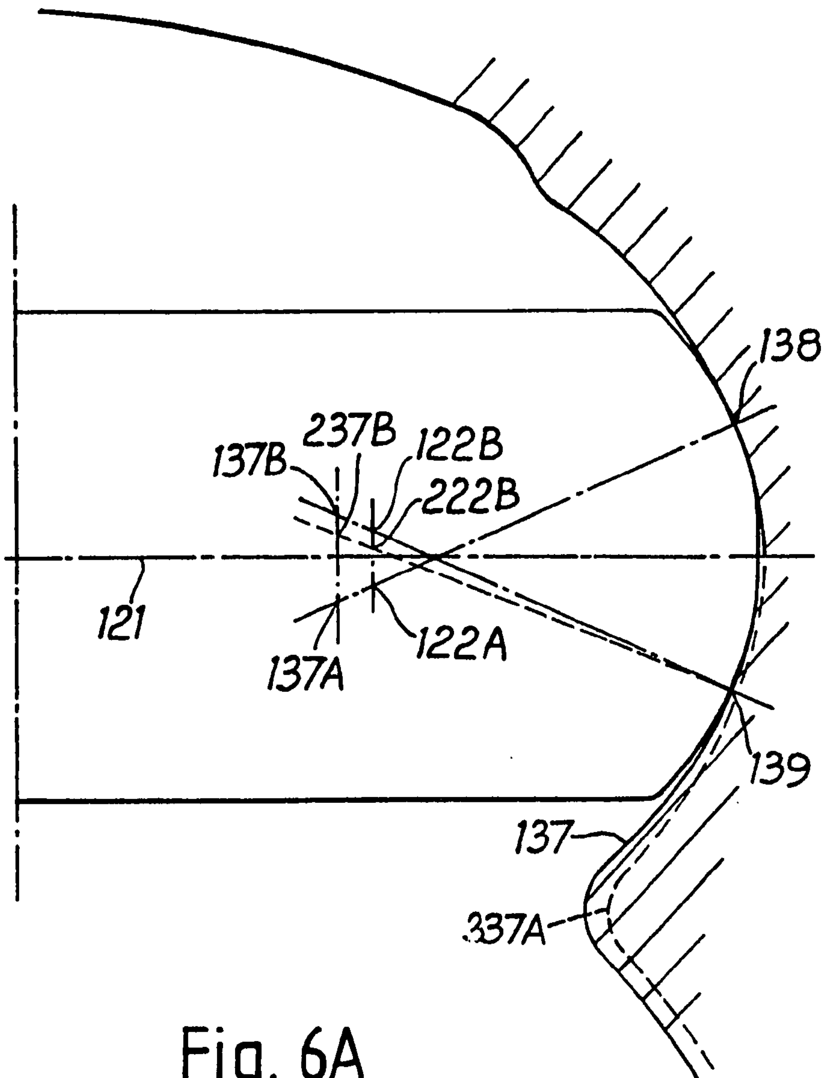

138
137B
237B
122B
222B
121
137A
122A
139
137
337A

Fig. 6A

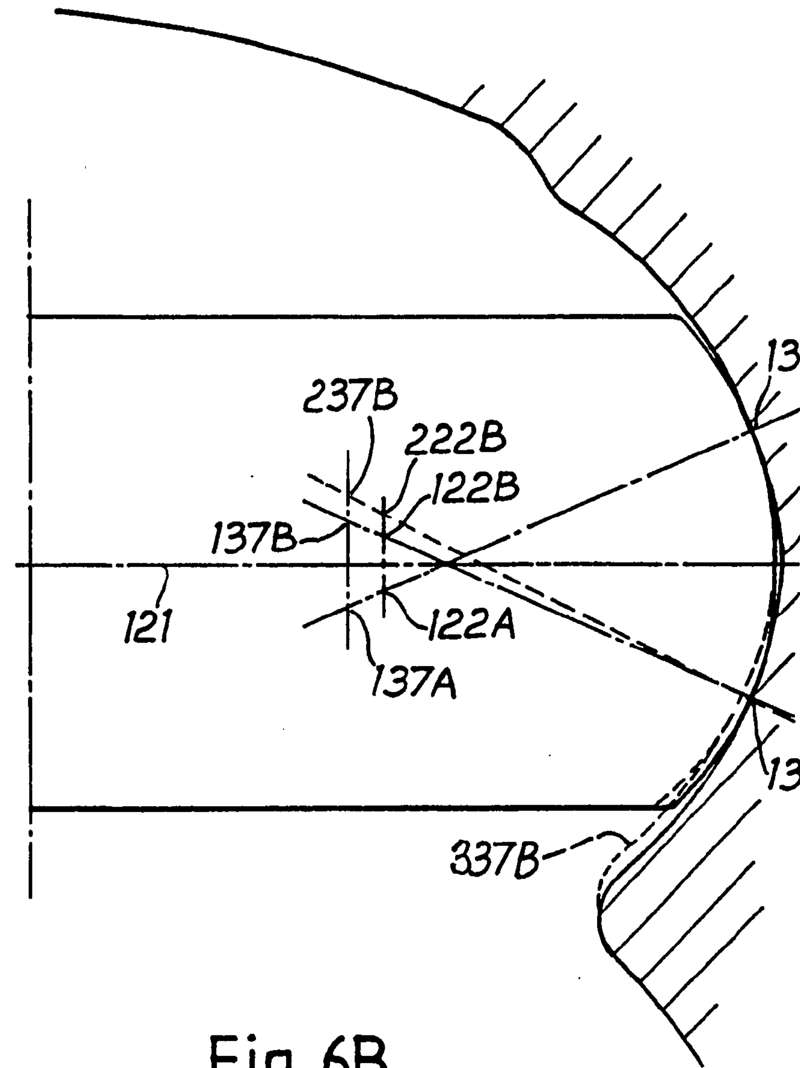

138
237B
222B
122B
137B
121
122A
137A
139
337B

Fig. 6B

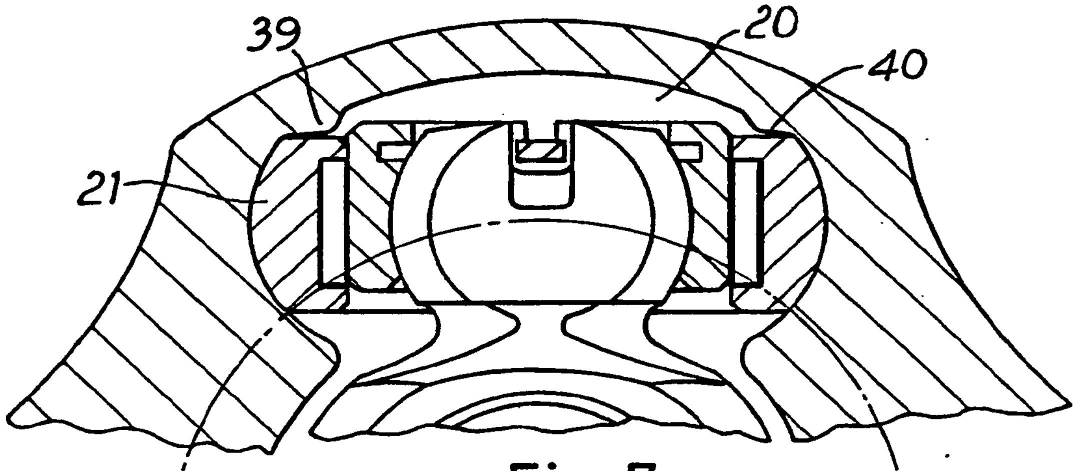


Fig. 7

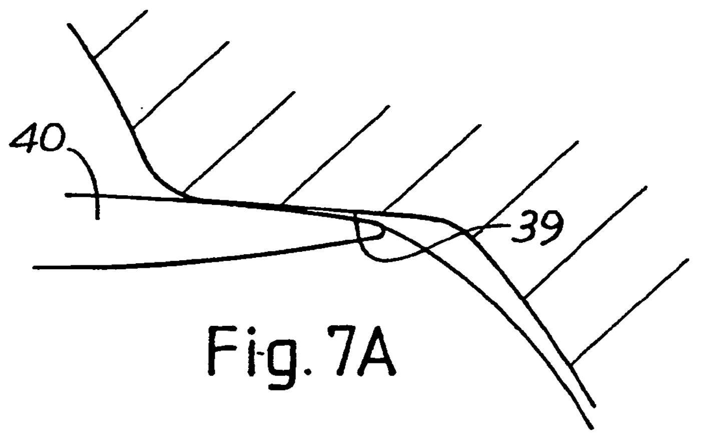


Fig. 7A

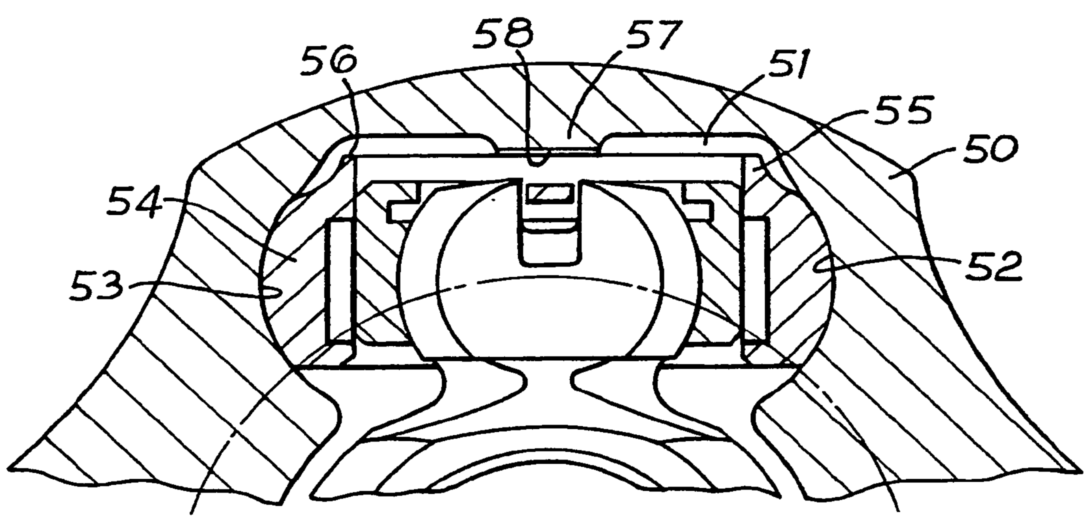


Fig. 8

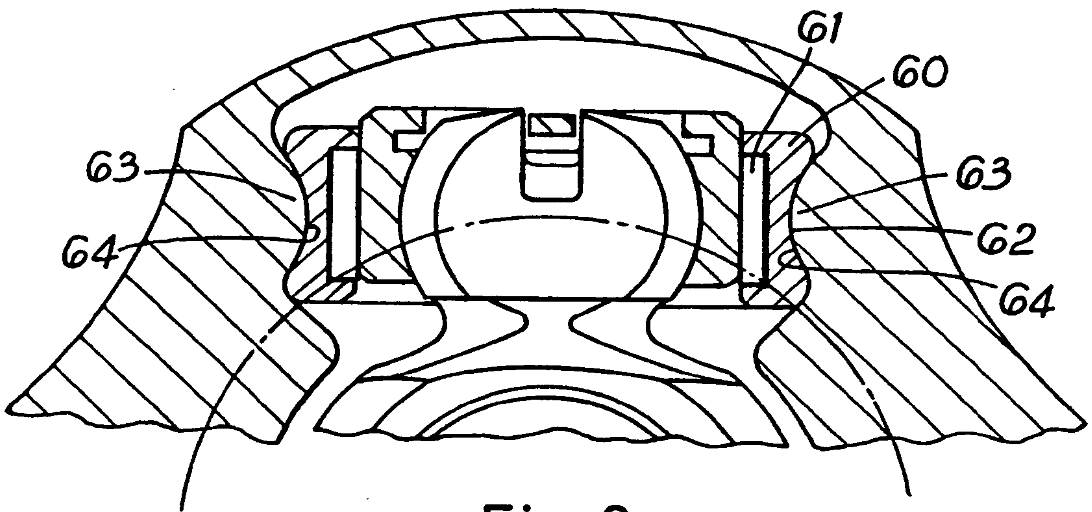


Fig. 9

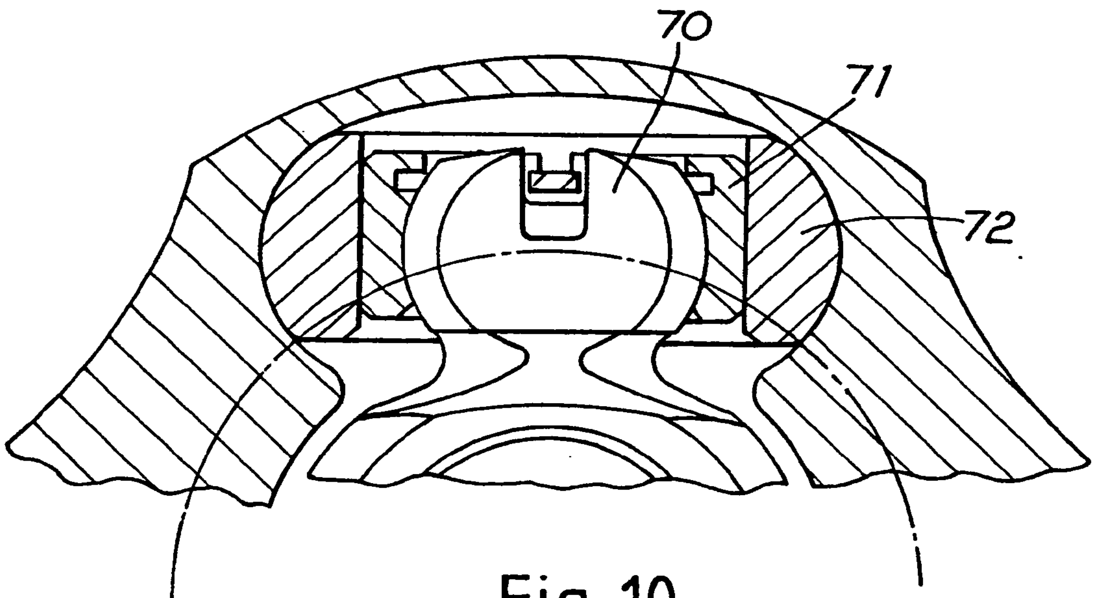


Fig. 10

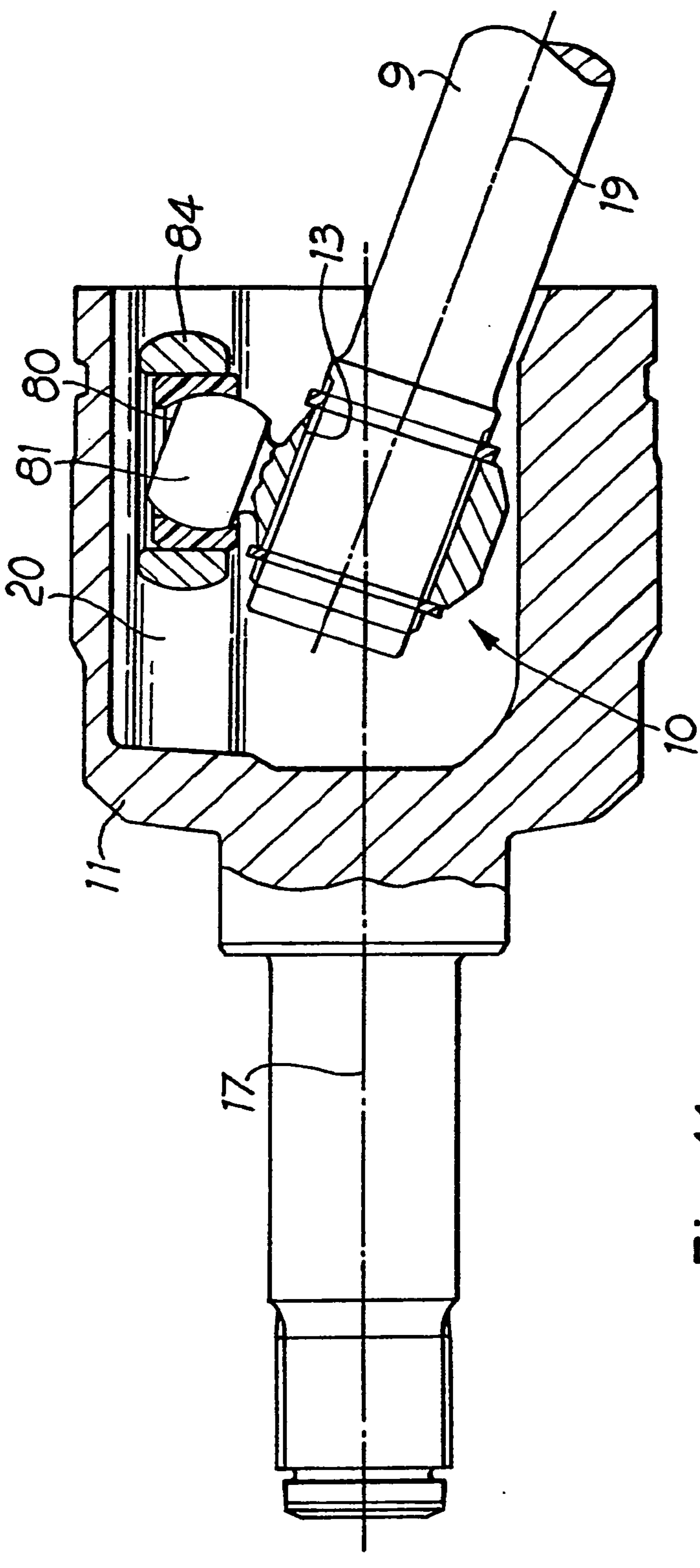


Fig. 11

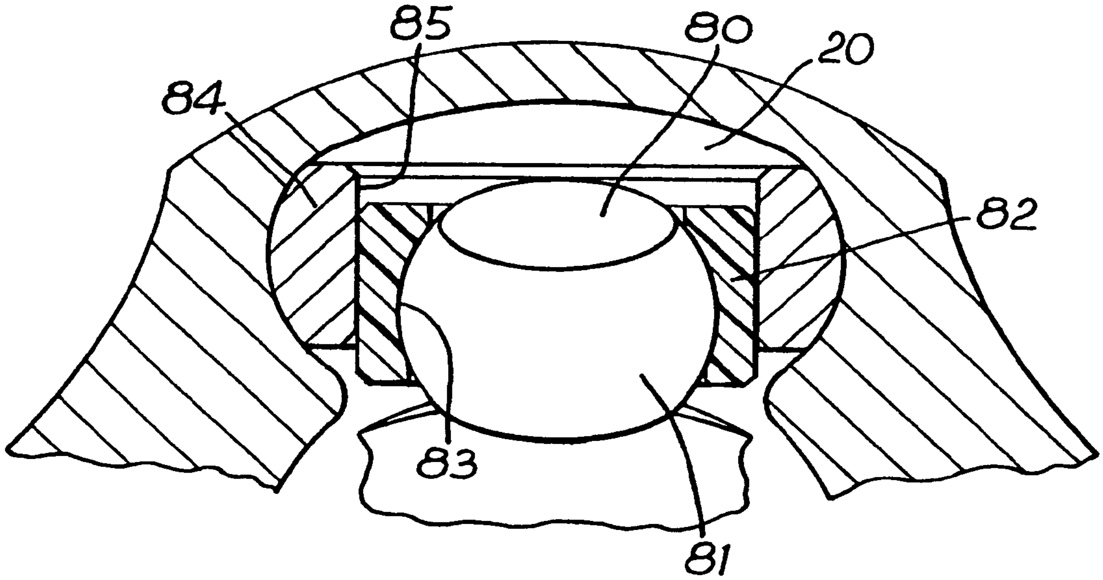


Fig. 12

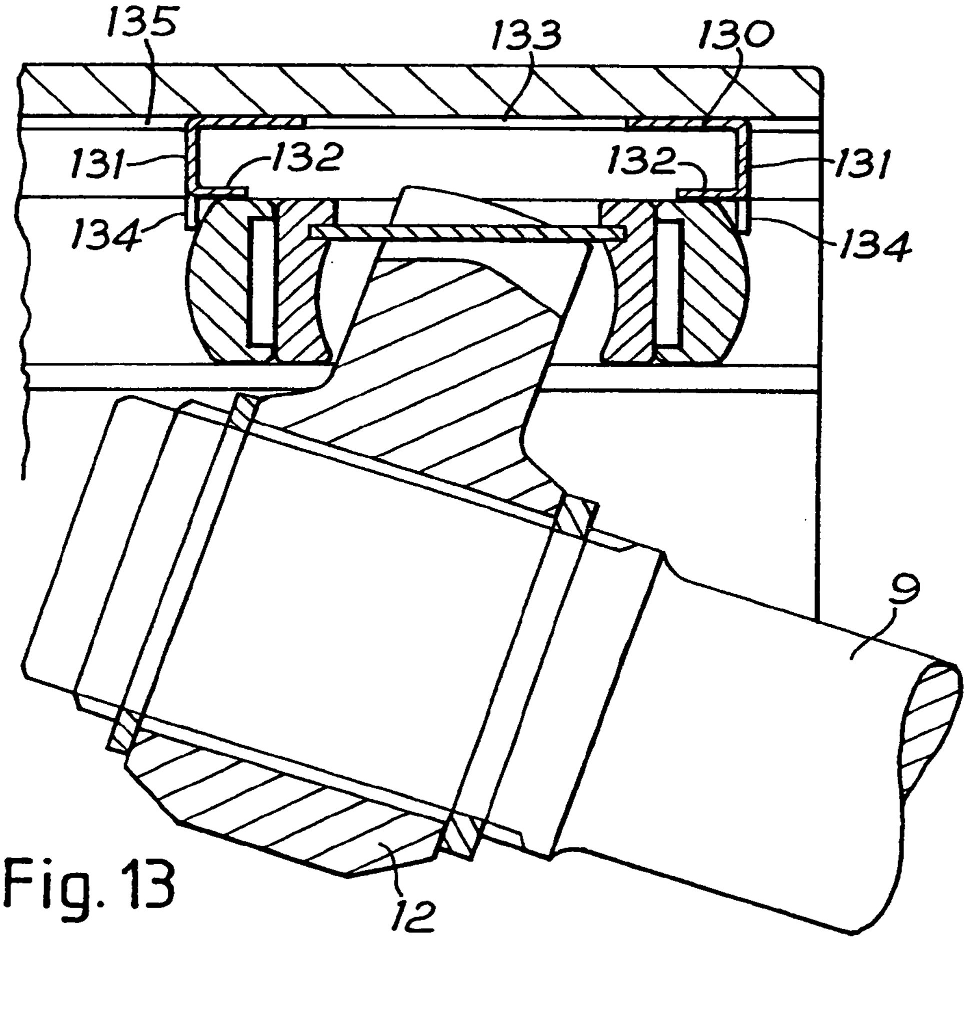


Fig. 13

GMD/88127GB1

CONSTANT VELOCITY RATIO UNIVERSAL JOINTS

This invention relates to constant velocity ratio universal joints of the tripod type. A joint of the type to which the invention relates comprises an outer joint member having a rotational axis and three guide grooves extending parallel to its rotational axis and equally circumferentially spaced thereabout; an inner joint member disposed inside the outer member, having a rotational axis and three arms equally spaced about this rotational axis extending radially into the guide grooves of the outer joint member; each arm carrying a roller which engages opposed side portions of the corresponding guide groove and is constrained to roll therealong; each roller being able to rotate about, slide lengthwise of, and tilt relative to the arm by which it is carried. Such a joint will hereafter be referred to as a tripod joint of the kind specified.

In a tripod joint of the kind specified, the constraint of each roller to rolling movement along its respective track in the outer joint member, without tilting relative thereto, means that the joint has a reduced frictional resistance to plunge (i.e. relative axial movement between the outer and inner joint members) and rotation when the joint is articulated. When the joint rotates in the articulated condition, each roller tilts relative to the arm by which it is carried rather than relative to the track in which it is engaged. It will be appreciated that if the roller tilted relative to the track, it would not be able to roll along the track but would have to slide therealong in the tilted condition, which obviously would produce a greater

frictional resistance to such movement, and have the result that the joint would tend to generate and transmit vibrations.

There have been various proposals for arrangements by which each roller is carried by its respective arm so as to be able to undergo the necessary rotational, sliding and tilting movement relative thereto. For example, in GB 2 018 393 there is disclosed a tripod joint of the kind specified wherein each arm has an outer cylindrical surface and each roller has an inner cylindrical surface, between these two surfaces there being disposed inner and outer guide rings which have interengaging part-spherical surfaces. A needle roller bearing is disposed between the outer surface of the outer guide ring and the internal cylindrical surface of the roller. In this arrangement, the roller is able to tilt relative to the arm by virtue of the interengaging part-spherical surfaces of the inner and outer guide rings. The inner guide ring is able to slide lengthways on the arm. The roller is able to rotate about the arm by virtue of the needle roller bearing between the outside of the outer guide ring and the inner cylindrical surface of the roller. Such an arrangement for supporting the roller on the arm, however, is relatively complex involving a large number of separate components and therefore is expensive to manufacture. Further, although the roller is able to rotate about the arm easily by virtue of the needle roller bearing disposed between the outside of the outer guide ring and the inner cylindrical surface of the roller, there is a relatively high resistance to sliding movement of the roller lengthwise of the arm. GB 2 018 393 A also discloses a tripod joint of the kind specified wherein each arm of

the inner joint member has a part-spherical surface, engaged by an internal part-spherical surface of a guide ring on which the roller is received. There is, however, no disclosure as to how such a joint is assembled.

There has also been a proposal, in DE-3722579, for a tripod type of universal joint wherein the arms of the inner joint member have part-spherical surfaces, which engage complementary part-spherical surfaces in the interior of inner roller elements. However, in this joint, the purpose of the inter-engaging part-spherical surfaces is to allow each roller assembly to pivot in a plane which also contains the axes of the three arms, and the roller assembly is prevented from pivoting in any other direction. When the joint is articulated, each roller tilts relative to its guide groove in the outer joint member, and has to slide therealong in the tilted condition. This is not, therefore, a joint of the kind specified.

It is broadly the object of the present invention to provide a tripod joint of the kind specified wherein the above referred to disadvantages of previously proposed joints, with regard to their performance and the manner in which they may be assembled, are overcome or reduced. Further advantages of joints according to the present invention will be particularly pointed out in the following description.

According to one aspect of the present invention, we provide a tripod joint of th kind specified wherein each of the arms of the inner joint member comprises a part-spherical surface, and the respective roller is carried thereon by an inner roller element having a part-

spherical internal surface engaging the part-spherical surface of the arm so as to be able to tilt thereon, the inner roller element having a cylindrical external surface on which the roller is able to rotate and move lengthwise of the arm, each of said arms of the inner joint member also having relieved portions facing in opposite directions along the axis of the inner joint member to provide for assembly of the inner roller element thereon.

In a joint according to the invention, the necessary tilting movement of each roller relative to the arm by which it is carried takes place at the interfitting part-spherical surfaces of the arm and inner roller element. Rotation of the roller relative to the arm, and the necessary sliding movement of the roller lengthwise of the arm take place between the internal surface of the roller and the cylindrical external surface of the inner roller element. The relative sliding movement of the roller lengthwise of the arm does not take place in isolation but in addition to rotation of the roller about the arm, so that the lengthwise movement is superimposed on an already existing rotation in the bearing and therefore takes place with minimum resistance.

Because the relieved portions of the arms of the inner joint member face in opposite directions axially thereof, leaving the part-spherical surface unbroken in directions tangentially of the inner joint member to engage the part-spherical internal surface of the inner roller element, when the joint is transmitting torque the forces applied between arm and inner roller element are between the interfitting part-spherical surfaces thereof. The axially facing relieved portions are not detrimental to the torque transmitting capability of the joint, and

provide the necessary clearance for the rollers to tilt on the arms.

The inner roller element may be provided, in its interior having the part-cylindrical surface, with diametrically opposed cutaways so that the inner roller element is able to be placed on the arm by moving it in a direction perpendicular to the rotational axis of the inner joint member, with the part-spherical surface portion of the arm passing through the internal cutaways of the inner roller element while the flats on the arm face the remaining part-spherical internal surface portions of the inner roller element. Then, when the inner roller element is suitably positioned on the arm, the inner roller element can be turned through 90° about the axis of the arm, perpendicular to the rotational axis of the inner joint member, so that the part-spherical surface portions of arm and inner roller element engage and the flats of the arm face the internal cutaways of the inner roller element. A retaining element is then fitted to the inner roller element to engage the arm to prevent a reverse of the 90° rotation of the inner roller element and ensure that it remains held to the arm. Such a retaining element preferably comprises a resilient member extending diametrically across the inner roller element, and engaging a slot provided in the end of the arm.

Alternatively, each inner roller element may be "sprung" onto its arm. This procedure involves deforming the inner roller element by applying oppositely directed forces thereto in the direction axially of the inner joint member, i.e. in the directions faced by the relieved portions of the arm. This causes an increase in the internal dimension of the inner roller element in the

direction tangentially of the inner joint member, to enable it to be fitted onto the arm. Thereafter, when the forces applied to the inner roller element are released, assuming the deformation of the inner roller element has not exceeded its elastic limit, the inner roller element once again assumes its original shape and is then held captive on the arm by virtue of the interengaging part-spherical surfaces of arm and inner roller element.

According to another aspect of the invention, we provide a tripod joint of the kind specified wherein each of the arms of the inner joint member comprises a part-spherical surface, and the respective roller is carried thereon by an inner roller element of plastics material moulded in situ on the arm so as to have a part-spherical internal surface engaging the part-spherical surface of the arm for tilting thereon, the inner roller element having a cylindrical external surface on which the roller is able to rotate and move lengthwise of the arm.

Further features of joints according to the invention relate to the engagement between each roller and its guide groove in the outer joint member, so that the roller is constrained to roll along the guide groove and not tilt therein, with the result that when the joint is articulated the roller tilts relative to the inner joint member. Each roller is an annular component, having an internal surface which engages the cylindrical external surface of the inner roller element. The external surface of the roller, which engages th opposed side portions of the guide groove, is a surface of revolution about a roller axis extending through the centre of the roller. In an aligned joint, the roller

axis is perpendicular to the axis of rotation of the inner joint member and coincides with the centre line of the arm on which the roller is carried.

Each roller is preferably constrained against tilting within its guide groove by the nature of the engagement between the external surface of the roller and the side portions of the guide groove it engages. Particularly, the roller external surface and each roller-engaging side portion of a guide groove may be so configured as to provide contact therebetween at two spaced points, so called angular contact. This may be achieved by having the roller-engaging side portion of the guide groove of gothic arch cross-sectional shape.

The external surface of the roller may be a surface of revolution of an arc about the roller axis, the centre of curvature of such arc being offset from the roller axis in order to provide the required angular contact with the side portions of the guide groove. Preferably, however, the external surface of the roller is a surface of revolution, about the roller axis, of a truncated gothic arch shape. The advantage of this configuration is described hereafter.

Such a mode of engagement between the roller and guide groove is effective to prevent the roller from tilting relative to the groove when the joint is actually transmitting torque, and to limit tilt of the roller when no torque is being transmitted.

In a joint according to the invention, each of the opposed roller-engaging side portions of each guide groove may comprise at least one shoulder portion engagable with a corresponding end face of the roller to

constrain the roller from tilting in the guide groove when no torque is being transmitted. The guide groove may present two such shoulder portions engagable with both end faces of the roller, or only one shoulder portion, engagable with the radially innermost or radially outermost (having regard to the joint as a whole), end face of the roller, as the case may be. Preferably the or each such shoulder is inclined so as to have line contact with the roller when the latter begins to tilt.

A further way in which tilting of rollers relative to the outer joint member can be prevented is by providing each roller with a part extending radially outwardly beyond the outermost end of the arm by which it is carried, and by providing each guide groove with an abutment surface engagable with an end face of the outwardly extending part of the roller, to constrain the roller from tilting.

Yet a further alternative is that a respective guide element may be provided engaging diametrically opposed parts of each roller and also engaging a base portion of the respective guide groove for sliding movement therealong, to constrain the roller from tilting in the guide groove.

In yet a further embodiment of joint according to the invention, each roller may have an external surface which is concave (preferably a concave gothic arch) as the roller is viewed in section, i.e. the external surface of the roller as a whole is diabolo shaped. Then the opposed sides of each guide groove may comprise ribs whose cross-sectional shape is complementary to that of the external roller surface, preferably to have angular

contact engagement therewith. Such a diabolo shaped roller cannot tilt substantially relative to the outer joint member.

A needle roller bearing assembly is preferably interposed between the external cylindrical surface of each inner roller and an internal surface of each roller. Then, the above described rotation, and relative sliding movement lengthwise of the arm, of the roller relative to the inner roller element takes place at such bearing, and there is a greatly reduced frictional resistance to these relative movements. However, it would be within the scope of the invention if a plain bearing were to be provided at this point.

The invention will now be described by way of example with reference to the accompanying drawings, of which:-

Figure 1 is an elevation, partly in section, of an embodiment of tripod joint according to the invention, in the articulated condition;

Figure 2 is an end view, partly in section, of part of the joint of Figure 1;

Figure 3 is a perspective view of the inner joint member of the joint of Figure 1 illustrating how an inner roller may be fitted thereto;

Figure 4 is a view as Figure 3 of an alternative inner joint member and mode of fitting an inner roller thereto;

Figure 5 is an enlargement of part of Figure 2, showing further detail of the configuration of a roller of the joint and guide groove side portion engaged thereby;

Figures 6A and 6B show diagrammatically further possible configurations of roller and guide groove;

Figure 7 is a view as Figure 2, showing a modification of the joint according to the invention;

Figures 8, 9 and 10 are views as Figure 2 showing yet further modified embodiments of joint according to the invention.

Figures 11 and 12 are views as Figures 1 and 2 of a further embodiment of joint according to the invention.

Figure 13 shows yet a further modification of a joint according to the invention.

Referring firstly to Figures 1, 2 and 3, a joint according to the invention comprises an inner joint member 10 and an outer joint member 11. The inner joint member, all of which is visible in Figures 1 and 3 but part only in Figure 2, comprises an annular body 12 provided in its interior with splines 13 for torque transmitting engagement with a shaft element 9. The axis of rotation of the inner joint member is indicated at 19. The inner joint member has three arms 14 extending radially outwardly from the body 12, equally circumferentially spaced around it. Each arm 14 comprises part-spherical surface portions 15 which face generally tangentially of the inner joint member, and flats 16 which face in opposite directions along the

rotational axis of the inner joint member. Only the flats 16 on the corresponding sides of the arms 14, facing the same direction as one another, are visible in Figure 3.

The outer joint member 11 is generally in the form of a cup-shaped component, in whose interior there are provided three guide grooves 20 extending into the outer joint member from the open end thereof and parallel to the rotational axis 17 thereof. One of such guide grooves 20 is shown in Figure 2. The arms 14 extend into the guide grooves 20, and each arm 14 carries a roller assembly comprising a roller 21 and an inner roller element 22. The roller 21 has an external surface 122 which engages opposed side portions 137 of the groove 20 in a manner to be described in greater detail hereafter, and the inner roller element 22 comprises a part-spherical internal surface 23 and a cylindrical external surface 24. A needle roller bearing assembly comprising a plurality of needle rollers 25 is interposed between the roller 21 and inner roller element 22, the needle rollers 25 running against the external cylindrical surface 24 of the inner roller element 22 and a recessed internal cylindrical surface 26 of the roller 21.

The roller 21 is thus able to rotate about the arm 14, slide lengthwise of the arm (i.e. in a direction perpendicular to the rotational axis of the inner joint member 10), and tilt relative to the arm 14. The rotation of the roller 21 and sliding movement thereof relative to the arm 14 take place at the needle roller bearing assembly interposed between the roller and inner roller element. The tilting of the roller takes plac by movement of the inner roller element 22 relative to the

arm 14 at the interengaging part-spherical surfaces thereof.

Further details of the configuration of the inner roller element 22 and the manner in which it is assembled onto the arm 14 are most clearly shown in Figure 3. In its interior having the part-spherical internal surface 23, the inner roller element 22 is provided with two diametrically opposed cutaways 27, most of one such cutaway and a small part only of the other being visible in Figure 3. These cutaways are so dimensioned that the inner roller element is able to be placed on the arm 14 by moving it in a direction perpendicular to the rotational axis of the inner joint member, i.e. lengthwise of the arm, with the part-spherical surface portions 15 of the arm passing through the cutaways 27 while the flats 16 on the arm face the remaining portions of the part-spherical internal surface 23 of the inner roller element between the cutaways 27. When the inner roller element has been thus placed on the arm, it is turned through 90° about the axis of the arm, perpendicular to the rotational axis of the inner joint member, as indicated by arrow 28. This causes the part-spherical surface portions 15 of the arm to engage the portions of the part-spherical internal surface 23 of the inner roller element, the flats 16 on the arm facing the cutaways 27. To retain the inner roller element in this orientation on the arm, whilst permitting the above described relative tilting movement to occur therebetween, a retaining element is fitted, in the form of a short strip 29 of resilient material, e.g. spring steel which extends diametrically across the inner roller element engaging in diametrically opposed parts of an undercut annular groove 30 adjacent the end face of the inner roller element. Lugs 31 at th ends of the

resilient retaining member 29 engage in diametrically opposed recesses 32 in the inner roller element, so that the retaining member 29 cannot move around the inner roller element. The retaining element 29 fits in a slot 33 extending into the arm 14 from the free end thereof, and parallel to the rotational axis of the inner joint member. The width of the retaining member 29 is less than that of the slot 33, so that tilting movement of the inner roller element can take place freely relative to the arm; the base of the slot 33 is not flat but in the form of two inclined surfaces to provide the necessary freedom to the inner roller element without unduly weakening the arm. Further, the inner roller element is able to pivot to a small extent universally on the arm: this assists in accommodating any slight misalignment which might arise between the components of the joint due to production tolerances, therefore helping the free-running characteristics of the joint.

The inner roller element 22 could, in an alternative construction, not be provided with the internal annular groove 30. The retaining element 29 could then be held to the inner roller element 22 by deforming the material of the latter in the region of the recesses 32 while the retaining element is in position. Of course, such deformation of the inner roller element must not distort the external cylindrical surface thereof in the region where it is engaged by the needle rollers 25 in service. A further alternative possibility is that the inner roller element would be provided with a diametrically opposed pair of apertures through which a pin could be inserted and retain d, to extend through the slot 33.

Referring now to Figur 4 of the drawings, there is shown an alternative configuration of inner joint member,

and inner roller element for assembly onto one of the arms thereof. In Figure 4, the inner joint member is indicated at 121 and its arms at 141. Each arm comprises part-spherical surface portions 151 facing tangentially relative to the rotational axis of the inner joint member, and flats 161 facing in opposite directions parallel to such axis, the flats 161 facing in one such direction only being visible in Figure 4. The inner roller element, indicated generally at 221, has a part-spherical internal surface 231, with no cutaways therein. Further, the inner roller element has no recesses as the recesses 32 in the embodiment of Figure 3, nor do the arms 141 have slots therein as the slots 33 in the embodiment of Figure 3.

To fit such an inner roller element to its arm, the inner roller element is deformed slightly by applying to it diametrically opposed forces as indicated by arrows 222 in Figure 4. This causes the internal dimension of the inner roller element to increase in the direction perpendicular to that in which the force is applied, until the inner roller element can be fitted onto the arm by moving in the direction lengthwise thereof. The inner roller element may have to be pressed on to the arm. When thus fitted, the release of the force which had been applied as indicated by arrows 222 enables the inner roller element to return to its circular shape, so that the part-spherical surfaces 151, 231 engage and the inner roller element is then held captive on the arm. It is, of course, important that the deformation of the inner roller element should be within the elastic range thereof so that it returns to its undeformed shape, and it will further be appreciated that this method of assembly will only be possible if the inner roller element is sufficiently thin walled to enable it to be deformed

enough to be fitted without excess force having to be applied thereto.

The inner joint member of either configuration above described would usually be manufactured by suitable machining operations on a forged blank. The flats on the arms would be present on the forged blank, and the part-spherical surface portions of the arms turned and ground to the required shape and surface finish while the flats would be left rough as forged. As well as providing for assembly of the inner roller elements, the flats provide clearance for the inner roller elements to tilt sufficiently on the arms to give the joint the required articulation angle capability, without requiring the arms to be provided with recesses or cutaways in the region of their roots where they join the annuar body part 12 of the inner joint member. The strength of the arms in respect of the torque capacity of the joint is primarily determined by the dimension of each arm at its root portion, in the direction circumferentially of the inner joint member: the cross-sectional shape of the root portion may be elongated in such circumferential dimension as compared with its dimension in the direction axially of the joint member.

The arms, at least on their part-spherical surface portions, may be treated so as to reduce friction between them and the inner roller elements. For example, the application of a low-friction coating to the arms can substantially reduce frictional resistance to tilting of the roller assemblies on the arms, thereby improving the performance of the joint.

The roller 21 is constrained not to tilt within the guide groove 20 in the outer joint member by virtue of

the manner in which the roller engages the opposed side portions of the guide groove. The external surface of the roller may be a surface of revolution of an arc about the roller axis extending through the centre of the roller, the centre of curvature of the arc being offset from such roller axis. Each side portion of the guide groove may have a surface of "gothic arch" shape as viewed along the guide groove, so as to have contact with the external surface of the roller at two spaced points. This mode of engagement between roller and side portion has the effect, when the joint is transmitting torque, of guiding the roller so as not to tilt relative to the outer joint member.

Preferably, however, the configuration of roller and guide groove is as shown in Figure 5 of the drawings. This is a section, perpendicular to the axis of rotation 17 of the outer joint member 10 and containing the axis indicated at 124 of the roller, which shows in detail the configuration of the external surface 122 of the roller and the side portion 137 it engages of the guide groove 20. The external surface of the roller is a truncated gothic arch shape in this section, comprising arcuate portions having respective centres of curvature 122A, 122B offset to opposite sides of the transverse centre plane, indicated at 121, of the roller. The side portion 137 of the guide groove 20 where it is engaged by the roller is a gothic arch shape in section, comprising arcuate portions with respective centres of curvature 137A and 137B also offset on opposite sides of the plane 121. The radii of curvature of the arcuate parts of the guide groove side portion 137 are slightly greater than the radii of curvature of the arcuate parts of the roller external surface, with the result that contact therebetween is established at two spaced "points" 138,

139 (in practice small elliptical areas when the joint is transmitting torque and deformation occurs as the roller is pressed against the groove side portion).

The above described engagement between the roller and guide groove side portion at two spaced points is the condition generally known as "angular contact". The angles indicated at P between the perpendiculars at the contact points and the roller centre plane 121 are known as the pressure angles. The condition of angular contact between the roller and guide groove has the effect, when torque is being transmitted, that the roller is guided so that it stays in alignment relative to the guide groove, with its axis 124 perpendicular to the rotational axis of the outer joint member. Any tendency for the roller to tilt in the guide groove so that its axis inclines to the axis of the outer joint member, in the same sense that axis 19 is inclined to the axis 17 in Figure 1, results in the establishment of a couple which tends to restore the roller to the correct alignment.

With the illustrated groove and roller configuration, the restoring couple established if there is any tendency of the roller to tilt is greater than if the cross-sectional shape of the external surface of the roller were (as previously referred to) a single arc of a radius chosen to provide angular contact with the track groove side portion at the same pressure angle. This is a result of the reduction of the rate at which the surfaces of the roller and groove side portion diverge from one another with increasing distance from the contact points therebetween, as they ar vi w d in cross-section.

When the roller attempts to tilt in the track, an increase in pressure angle occurs with a consequent increase in the offset of the contact "points" 138, 139 from the roller central plane 121. With the gothic arch sections of roller and groove, the rate of change of the offset distance X relative to the rate of change of pressure angle P is greater than can be achieved with a roller whose external surface is in the section of a single arc.

In design of a roller and guide groove for angular contact, one wants to achieve a predetermined pressure angle and, in order to provide sufficient load carrying capacity, conformity ratio between the local radii of curvature of the guide groove side portions and contacting parts of the roller external surface. Within such constraints, the gothic arch sections of the roller surface and guide groove can provide the improved resistance to tilting of the roller. It can be shown that when the guide groove side portion is of gothic arch cross section and the external surface of the roller is arcuate in section, it is not possible to achieve the required conformity of curvature between the roller and groove side portion surfaces to give the necessary load carrying capacity, unless the pressure angle is changed adversely.

As shown in Figure 5, both the external surface of the roller and the shape of the side portion of the guide groove are symmetrical about the plane 121. The centres of curvature 122A, 122B are equally offset from the plane 121. However, one problem in the production of the outer joint members of tripod joints and the provision of the guide grooves therein by a forming process is that of distortion, arising from the manufacturing process and

from heat treatment. The result of such distortion is that the gothic arch cross-sectional shape of the side portion of the guide groove may be misaligned or non-symmetrical about the plane 121, so that it is not engaged by the roller with equal pressure angles. This could then lead to scuffing of the roller as it rolls along the guide groove.

If, however, the nature of such distortion can be predicted, it is possible to make the roller itself asymmetrical so that it engages the groove side portion correctly. Figures 6A and 6B show possible such distorted guide groove configurations, and asymmetric roller configurations to engage correctly therewith.

Figure 6A shows, in a broken line indicated at 337A, one possible deviation of the guide groove side portion from the symmetrical configuration thereof indicated at 137. The centre of curvature of the corresponding arcuate part of the gothic arch section of the guide groove side portion is indicated at 237B, offset from the plane 121 by a lesser distance than the centre of curvature 137A of the undistorted surface part. To compensate for such distortion, the centre of curvature 222B of the corresponding arcuate part of the gothic arch section of the external surface of the roller is offset from the plane 121 by a lesser distance than is the centre of curvature 122A of the other arcuate part of the roller surface.

Figure 6B shows an alternative condition wherein distortion of the joint outer member has produced a surface 337B whose centre of curvature, at 237B, is offset from the plane 121 by a greater distance than is the centre of curvature 137A of the other part of the

gothic arch section of the groove side portion. To compensate for this, the centre of curvature 222B of the corresponding arcuate part of the gothic arch section of the roller is offset from the plane 121 by a greater distance than is the centre of curvature 122A of the other arcuate section of the roller's external surface.

Although it is convenient for the gothic arch cross sectional shape of the guide groove side portion and of the roller external surface to comprise respective arcuate portions whose radii and centres of curvature can be selected as above described with the possibility of compensating for joint outer member distortion, the same benefits in terms of improved control of roller alignment can be obtained with other gothic arch surface shapes. In particular, the surfaces of the roller and/or guide groove side portion where they engage could be of part-elliptical or part-involute section. This could lead to a further reduction of the rate at which the surfaces of the roller and groove side portion diverge from one another with increasing distance from the contact points therebetween, as they are viewed in cross-section.

As above described, the nature of the engagement between the roller and each guide groove side portion is effective, when the joint is transmitting torque, to resist any tendency of the roller to tilt within the guide groove. However, production tolerances necessarily mean that there will be some clearance between roller and guide groove in the direction diametrically of the roller, and when the joint is not transmitting torque the roller will tend to move away from the guide groove side portion it was previously engaging. Even with the gothic arch/gothic arch configuration of the surfaces of

the roller and guide groove side portion according to the invention, the roller will then be able to tilt to some extent before clearances are absorbed and no further tilting is possible. In a motor vehicle, unless such tilting is prevented, the result may be transmission and generation of noise and vibration under operational conditions involving the transmission of low or zero torque, and frequent torque reversals. Therefore it may in certain circumstances be desirable to provide the joint with means for positively preventing the rollers from tilting (although in other circumstances the improved resistance to roller tilting in a joint according to the invention may be adequate without requiring such additional provision).

Some embodiments of such additional means for preventing the rollers from tilting in the guide grooves in the outer joint member are shown in the following figures of drawings.

Figure 7 shows, in a view corresponding to that of Figure 2, an outer joint member whose guide groove 20 is provided, adjacent its side portions engaged by the external surface of the roller, with guide shoulders 39. The shoulders are engagable with the end face 40 of the roller 21 and arranged such that when the roller is exactly aligned in the guide groove, with its axis perpendicular to the axis of rotation of the outer joint member, there is a very slight clearance between the shoulders and end face of the roller. As soon as the roller begins to tilt, it contacts the shoulder and substantial tilting is prevent d. Alt rnatively or in addition, shoulders engagabl with the opposite end face of the roller may be provided.

Figure 7A shows in greater detail one of the shoulders 39, and illustrates that the shoulder is inclined so as to have line contact with the edge of the end face of the foller when the roller begins to tilt.

Referring now to Figure 8 of the drawings, this shows an alternative configuration of outer joint member and the guide groove therein, and the roller carried by the arm of the inner joint member. The inner roller element engaging the part-spherical surface of the arm of the inner joint member is the same as in the above described embodiments, and therefore will not be further referred to.

In Figure 8 there is shown an outer joint member 50 with a guide groove indicated generally at 51, having opposed side portions 52, 53 which engage the external surface of a roller 54 with the two point angular contact as above described. The roller 54 engages the inner roller element with the intermediary of a needle roller bearing assembly in the same manner as above described. In this embodiment, however, the roller has an annular extension 55 which extends radially outwardly (of the joint as a whole) beyond the end of the arm of the inner joint member and terminates in an end face 56.

The guide groove 51 is provided with a radially inwardly extending rib 57 having a flat abutment surface 58, facing the end of the arm of the inner joint member.

When there is any tendency of the roller 54 to tilt relative to the outer joint member, when torque is not being transmitted, the surface 58 is engagable with the end face 56 of the roller extension 55. When torque is

being transmitted, however, these surfaces are slightly spaced from one another as shown in the drawing.

Figure 9 shows a further embodiment of joint according to the invention. The inner joint member, arms thereof, and inner roller elements supported on the arms by needle roller bearings are all identical to the corresponding components of the joints described above. The roller, 60, has a recessed interior surface containing needle roller bearings 61 as above described. The external surface 62 of the roller is, however, of concave gothic arch section so that the roller as a whole is diabolo shaped. Opposite sides of the guide groove in the outer joint member are provided with longitudinally extending ribs 63 with opposed surfaces 64 which engage the external surface 62 of the roller. The surfaces 64 are preferably of gothic arch cross-sectional shape, to provide for angular contact with the roller surface 62 in the manner above described. By virtue of this mode of engagement between the external surface of the roller and the opposed sides of the guide groove, the roller cannot tilt substantially relative to the outer joint member and will roll therealong when the joint plunges and/or rotates in the articulated condition.

In all the embodiments above described, a needle roller bearing assembly is interposed between the external cylindrical surface of each inner roller and an internal surface of the respective roller. However, it would be within the scope of the invention if a plain bearing were to be provided at this point. Referring now to Figure 10 of the drawings, this shows a part of a joint with an inner joint member whose arm 70 carries a roller assembly with an inner roller element 71 and roller 72 which engages the guide groove in the outer

joint member as above described. In this embodiment, however, the inner roller element 71 is made of a suitable material such as a plastics or sintered metallic bearing material, such that the needle roller bearing assembly is not required between it and the roller 72. The inner roller element 71 is fitted to the arm 70 in the same manner as above described with reference to Figure 3 of the drawings.

A further possibility is that, if the inner roller element is made of a plastics material, it may be moulded in situ on the arm 70. In this case, there would be no necessity for the arm to have the opposed flats 16 and groove 33 for the retaining element, and for the inner roller element to be shaped to cooperate with the arm and retaining element. Figures 11 and 12 are respectively a partly sectioned elevation corresponding to Figure 1, and a partly sectioned partial end view corresponding to Figure 2, of a joint according to this embodiment. As in the embodiment of Figure 1, the joint comprises an inner joint member 10 and an outer joint member 11, the inner joint member comprising an annular body 12 provided in its interior with splines 13 for torque transmitting engagement with a shaft element 9 having a rotational axis 19. Three arms 80 extend radially outwardly from the body 12, equally circumferentially spaced around the body, and each arm 80 has a surface 81 of truncated spherical form, i.e. a part-spherical surface which extends all the way around the arm.

The outer joint member 11 is in the form of a cup-shaped component with three guide grooves 20 in its interior, extending from the open end thereof and parallel to the rotational axis 17 of the joint member. The arms 80 extend into the guide grooves, and each arm

carries a roller assembly comprising a roller 84 and inner roller 82. The inner roller element 82 has an internal part-spherical surface 83 extending all the way around its internal periphery and, since the inner roller element has been moulded in situ on the arm 80, this internal surface exactly matches the surface 81 of the arm so that the inner roller element is able to tilt on the arm. The inner roller element has a cylindrical external surface with which an internal cylindrical surface 85 of the roller 84 engages, so that the roller 84 is able to slide on and rotate about the inner roller element.

The configuration of the external surface of the roller 84, and of the opposed side portions of guide groove 20 which it engages, are preferably of the preferred form described above in relation to Figures 5 and 6 of the drawings. Further, any of the additional expedients described herein for preventing tilting of the rollers of the joint in their guide grooves under certain conditions may be adopted as required.

A further alternative is to have inner roller elements which are diametrically split to enable them to be fitted to the arms of the inner joint member. When the rollers are fitted to the inner roller elements, the latter are held together and captive on the arms of the inner joint member.

Referring finally now to Figure 13 of the drawings, there is shown yet a further means for preventing tilting of a roller 21 in its guide groove. This is a guide lement comprising a base portion 130 which is flat and lies against a complementary base portion 135 of guide groove 20. Two limbs 131 extend radially inwardly of the

joint as a whole, from the base portion 30, at opposite end thereof. Each limb 131 terminates in two spaced tabs 134 which lie in the external peripheral surface of the roller 21, and inwardly bent tongues 132 which lie against the flat end surface of the roller. The guide element is of resilient sheet material, e.g. spring steel.

CLAIMS

1. A tripod joint comprising an outer joint member having a rotational axis and three guide grooves extending parallel to its rotational axis and equally circumferentially spaced thereabout; an inner joint member disposed inside the outer member, having a rotational axis and three arms equally spaced about this rotational axis extending radially into the guide grooves of the outer joint member; each arm carrying a roller which engages opposed side portions of the corresponding guide groove and is constrained to roll therealong; each roller being able to rotate about, slide lengthwise of, and tilt relative to the arm by which it is carried; wherein each of the arms of the inner joint member comprises a part-spherical surface, and the respective roller is carried thereon by an inner roller element having a part-spherical internal surface engaging the part-spherical surface of the arm so as to be able to tilt thereon, the inner roller element having a cylindrical external surface on which the roller is able to rotate and move lengthwise of the arm.

2. A joint according to Claim 1 wherein each arm of the inner joint member has relieved portions facing in opposite directions along the axis of the inner joint member, to provide for assembly of the inner roller element thereon.

3. A joint according to Claim 2 wherein the inner roller element is provided, in its interior having the part-spherical surface, with diametrically opposed cutaways so that the inner roller el ment is able to be placed on the arm by moving it in a direction perpendicular to the rotational axis of the inner joint

member, with portions of the part- spherical surface of the arm passing through the cutaways of the inner roller element while the relieved portions on the arm face the remaining part-spherical internal surface portions of the inner roller element, whereafter the inner roller element can be turned through 90° so that the part-spherical surfaces of the arm and inner roller element engage.

4. A joint according to Claim 3 further comprising a retaining element fitted to the inner roller element and engaging the arm to prevent turning of the inner roller element and ensure that it remains held to the arm.

5. A joint according to Claim 4 wherein the retaining element comprises a member extending diametrically across the inner roller element, and engaging a slot provided in the end of the arm.

6. A joint according to Claim 2 wherein the inner roller element is able elastically to be deformed by application of forces thereto in the directions faced by said relieved portions of the arm, to increase the transverse internal dimension of the inner roller element and to enable it to be fitted to the arm by movement lengthwise thereof.

7. A tripod joint comprising an outer joint member having a rotational axis and three guide grooves extending parallel to its rotational axis and equally circumferentially spaced thereabout; an inner joint member disposed inside the outer member, having a rotational axis and three arms equally spaced about this rotational axis extending radially into the guide grooves of the outer joint member; each arm carrying a roller which engages opposed side portions of the corresponding

guide groove and is constrained to roll therealong; each roller being able to rotate about, slide lengthwise of, and tilt relative to the arm by which it is carried; wherein each of the arms of the inner joint member comprises a part-spherical surface, and the respective roller is carried thereon by an inner roller element of plastics material moulded in situ on the arm so as to have a part-spherical internal surface engaging the part-spherical surface of the arm for tilting thereon, the inner roller element having a cylindrical external surface on which the roller is able to rotate and move lengthwise of the arm.

8. A joint according to any one of the preceding claims wherein each opposed roller-engaging side portion of each guide groove has contact with the external surface of the roller at two spaced points, as viewed along the guide groove.

9. A joint according to Claim 8 wherein the guide groove side portion is of gothic arch cross-sectional shape, and the external surface of the roller is a surface of revolution, about an axis of the roller, of an arc whose centre of curvature is offset from the roller axis.

10. A joint according to Claim 8 wherein each roller-engaging side portion of a guide groove is of gothic arch cross-sectional shape, and the external surface of the roller is a surface of revolution, about an axis of the roller, of a shape including gothic arch portions.

11. A joint according to any one of the preceding claims wherein each opposed roller-engaging side of each guide groove comprises at least one shoulder engagable with a corresponding roller end face to prevent the roller from tilting substantially in the groove when torque is not being transmitted.

12. A joint according to Claim 11 wherein said shoulder is inclined so as to have line contact with the roller when the latter begins to tilt.

13. A joint according to any one of Claims 1 to 10 wherein each roller has a part extending radially outwardly (of the joint as a whole) beyond the outermost end of the arm by which the roller is carried, and each guide groove has an abutment surface engagable with an end face of the roller part to constrain the roller from tilting in the guide groove when torque is not being transmitted.

14. A joint according to any one of Claims 1 to 10 wherein the external surface of each roller is concave as viewed in section, and the side portions of each guide groove comprise opposed projecting ribs.

15. A joint according to any one of the preceding claims wherein a needle roller bearing assembly is interposed between the external cylindrical surface of each inner roller and an internal surface of each roller.

16. A joint according to any one of Claims 1 to 10 further comprising a respective guide element engaging diametrically opposed parts of each roller and also engaging a base portion of the respective guide groove

for sliding movement therealong, to constrain the roller against tilting in the guide groove.

17. A joint according to any one of the preceding claims wherein the arms are provided, at least on their part-spherical surfaces, with a low friction surface treatment.

18. A tripod universal joint substantially as hereinbefore described with reference to Figures 1 to 3, or Figures 11 and 12, or as modified in accordance with any one of Figures 4 to 12 or Figure 13, of the accompanying drawings.

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